

## 5. Correlated Noise

# Correlated Noise

Claim Term	CMU's Construction	Marvell's Construction
<p>correlated noise</p> <p>'839 Patent Claims 2 and 5 '180 Patent Claim 1</p>	<p>noise with 'correlation' among 'signal samples,' such as that caused by coloring by front-end equalizers, media noise, media nonlinearities, and magnetoresistive (MR) head nonlinearities.</p> <p>CMU Brf. at 19</p>	<p>noise having nonzero 'covariance' (see construction of 'covariance' above).</p> <p>Marvell Brf. at 32-33</p>

- The Dispute
  - ▶ Should "correlated noise" be accorded its ordinary meaning in engineering and statistics (Marvell) or its lay meaning with a list of examples (CMU)?

# Claim Language

- Method refers to a generic list of noise types

**2.** The method of claim 1 further comprising the step of receiving said signal samples, said signal samples having signal-dependent noise, **correlated noise**, or both signal-dependent and correlated noise associated therewith.

'839 Patent Claim 2

**5.** The method of claim 4 further comprising the step of receiving said signal samples, said signal samples having signal-dependent noise, **correlated noise**, or both signal-dependent and correlated noise associated therewith.

'839 Patent Claim 5

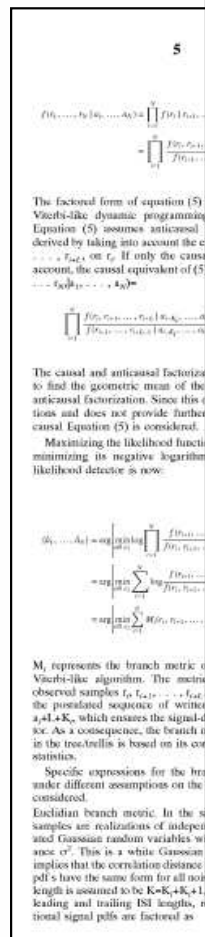
See also '180 Patent Claim 1

# Specification

- Patents describe correlated noise using mathematical terms

**Correlation-sensitive branch metric.** In the most general case, the **correlation length is  $L>0$** . The leading and trailing ISI lengths are  $K_l$  and  $K_t$ , respectively. **The noise is now considered to be both correlated and signal-dependent. Joint Gaussian noise pdfs are assumed.** This assumption is well justified in magnetic recording because the experimental evidence shows that the dominant media noise modes have Gaussian-like histograms. The conditional pdfs do not factor out in this general case, so the general form for the pdf is:

$$\frac{f(r_{i+1}, \dots, r_{i+L} \mid a_{i-K_l}, \dots, a_{i+L+K_t})}{f(r_i, r_{i+1}, \dots, r_{i+L} \mid a_{i-K_l}, \dots, a_{i+L+K_t})} = \sqrt{\frac{(2\pi)^{L+1} \det C_i}{(2\pi)^L \det c_i}} \frac{\exp[\underline{N}_i^T C_i^{-1} \underline{N}_i]}{\exp[\underline{n}_i^T c_i^{-1} \underline{n}_i]} \quad (11)$$



'839 Patent 6:36-52

# Extrinsic Evidence: Technical Treatises

- Marvell construction identical to statistical meaning
  - ▶ Uncorrelated variables have zero covariance
  - ▶ Correlated variables have nonzero covariance

If  $\text{Cov}(X_1, X_2) = 0$ , then the random variables  $X_1$  and  $X_2$  are said to be *uncorrelated*; if  $\text{Cov}(X_1, X_2) \neq 0$ , then they are *correlated*. Independent random variables are always *uncorrelated*, but correlated random variables are not necessarily independent in general.

Polyanin and Manzhirov, *Handbook of Mathematics for Engineers and Scientists*, at 1061 (2007) (Marvell Exh. 36)

## 2.3.2 Correlation and Covariance

Two random variables are said to be *uncorrelated* if  $E(X_i X_j) = E(X_i)E(X_j) = m_i m_j$ . In that case, the covariance  $\mu_{ij} = 0$ . We note that when  $X_i$

The second joint *centralized* moment is called the *covariance*, and is denoted by  $K_{XY}$ :

$$K_{XY} \triangleq E\{(X - m_X)(Y - m_Y)\}. \quad (2.21)$$

It is easily shown (exercise 3) that

$$K_{XY} = R_{XY} - m_X m_Y. \quad (2.22)$$

The correlation and covariance are each important measures of the interdependence of two random variables. If

$$K_{XY} = 0, \quad (2.23)$$

then  $X$  and  $Y$  are said to be *uncorrelated*. This terminology results from the fact that  $K_{XY}/\sigma_X \sigma_Y$  is referred to as the *correlation coefficient*. If

John G. Proakis,  
*Digital Communications*, at 35 (3d ed. 1995)  
(Marvell Exh. 35);  
See also Proakis Decl. at ¶¶ 42-43

Gardner, *Introduction to Random Processes with Applications to Signals and Systems*, at 32-33 (1986) (Marvell Exh. 24)

# CMU's Arguments Fail

- CMU's construction is grounded in its incorrect construction of correlation.
- CMU's list of examples from the specification is not helpful and improper.
  - ▶ “[A]lthough the specification often describes very specific embodiments of the invention, we have repeatedly warned against confining the claims to those embodiments.” *Phillips*, 415 F.3d at 1323.
  - ▶ “This Court has cautioned against limiting the claimed invention to preferred embodiments or specific examples in the specification.”  
*Texas Instruments, Inc. v. U.S. Int’l Trade Comm’n*, 805 F.2d 1558, 1563 (Fed. Cir. 1986).